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Financing Cleantech SME Innovation: Setting an Agenda

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Abstract

The need for a clear research and policy agenda to assist early stage Cleantech financing has never been greater. These businesses may hold important keys to unlocking vital globally game changing technologies to tackle climate change. The paper provides an overview of recent academic literature and proposes a research agenda for early stage Cleantech SME finance. With growing interest in how to support innovations that tackle the climate emergency, there is a need for evidence that can assist the private sector, civil society organizations and policymakers in finding more effective ways to encourage impact investing and other finance for early stage Cleantech SMEs. This research agenda will therefore contribute to sustainability transitions in key sectors and the development of a sustainable low carbon economy.

Managerial Relevance Statement

The paper has considerable relevance to practitioners, notably Cleantech SME managers, impact investors, the wider Cleantech business support ecosystem and policymakers. Academic research into the financing of early stage Cleantech innovation has been limited. However, it is increasingly urgently required as key element in tackling climate change, since the nurturing and commercialization of Cleantech SME innovation should be an essential part of overarching Green Deal style policies.

This paper provides an initial review of contemporary academic literature, offering insights into the diverse, and yet limited, approaches to assisting Cleantech early stage financing, exploring different perspectives of the actors in the entrepreneurial finance ecosystem and the academic approaches to improving understanding and informing policy.

The paper concludes by suggesting that a research framework is required to better integrate the diverse research literature to improve understanding of the definition and taxonomies of Cleantech activities, improve provision and accessibility to early stage Cleantech innovation financing, improve understanding of how to increase private sector impact investment into earlier innovation stages and develop and adopt standardized approaches to assist investors and policymakers to select investments and evaluate their wider environmental sustainability impacts.

Introduction: Why A Cleantech Early Financing Research and Policy Agenda is Required

The threats of climate change require innovations in Cleantech to help the transition to a low carbon circular economy. SMEs innovating with cleantech in a range of sectors can provide solutions, but there is currently a finance gap. This paper sets out a research agenda to build evidence about this gap and potential solutions.

Whilst environmental issues first surfaced at the United Nations Conference on the Human Environment in Stockholm in 1972, arguably only since the Paris 2015 agreement to reduce greenhouse gas emissions have there been significant efforts globally to ensure that industrial carbon emissions do not peak above a 2°C rise in temperature and prevent climate change catastrophe (Climate Focus, 2015). The urgency to scale up action has never been greater. Society has a narrowing window of just over a decade (by 2030) to implement radical reductions (45-50%) in global greenhouse gas emissions. Realizing this target will require a speed of global decarbonisation six times faster than has been achieved thus far (Bernstein et al, 2017; EIT Climate-KIC, 2018) and entail an industrial transition to net zero emissions in Europe by 2050 the very latest (Wyns et al., 2019; Clift, 2007).

The prevailing 'neoliberal', Friedman (1970) - type policies of deregulation and light touch governance are being challenged. Whilst they encouraged private business growth and proliferation of small and medium-sized enterprises (SMEs) during the post 1970s deindustrialisation era, they are now increasingly under scrutiny (Gazheli et al, 2016).

Left to its' own devices, the market appears unlikely to adjust quickly enough to progress to a low carbon economy in time to address the Paris agreement, never mind the more ambitious calls, such as by Finland and Norway for carbon neutrality in the next two decades (The New

York Times, 2019). In this paper we examine the problem of early stage Cleantech funding.

These are typically SMEs that are developing low carbon technologies leading to climate change 'green' efficiencies across a wide range of sectors, including renewable energy, transport, recycling, advanced manufacturing, construction, food and biotech (Polzin, 2017; Owen et al, 2019).

The dilemma of market growth and greenhouse gas emission is widely believed to be addressable through green technology innovations such as renewable energy supplies and efficient end-use (Du and Li, 2019; Knuth, 2018). By that reducing CO₂ emission significantly and alleviate grave impacts of climate change. We argue that cleantech SME innovation financing should be an essential cornerstone of policies to tackle climate change, since such businesses have the potential to develop globally significant game changing technologies to address future low carbon economic requirements if they can successfully scale their business model (Owen et al, 2019; Lerner 2010, 2012, Popp, 2012).

Yet, despite this need, insufficient financing exists (Cumming et al., 2017). Through a recent review of the academic literature we demonstrate that this is an under researched area and neglected by public policy, which has tended to focus on larger scale energy and infrastructure projects (Hafner et al, 2020; Mazzucato and Semieniuk, 2018). We conclude by setting out a research agenda to underpin this much needed area of policy development.

The problem with early stage Cleantech funding

Essentially, market failures exist in the early stage Cleantech financing market. These are driven by a combination of information asymmetries and the under-valuation of social and environmental benefits (Owen et al, 2019). Put simply, the balance of risk versus reward is tipped against Cleantechs - the key businesses that are developing low carbon innovations to address climate change (Polzin, 2017). Furthermore, that balance becomes more extreme against smaller, earlier stage innovative businesses that lack a track record and collateral (Carpenter and Petersen, 2002). Yet, as an abundance of SME innovation finance studies demonstrate (Owen et al 2019, 2019a; Lee et al, 2015, North et al, 2013; Lerner, 2012, 2010) these key innovation actors have potential to make significant contributions to sustainability transitions in a wide range of sectors, such as energy, transport, recycling, construction, advanced manufacturing and engineering, food and biotech (Polzin, 2017; Owen et al, 2019).

Within more mature finance markets, there has been a considerable rise in environmental impact investing, spurred by a combination of raised climate change awareness and post Global Financial Crisis innovations in entrepreneurial finance. These have included crowdfunding and peer to peer lending, green bonds, accelerators, new forms of business angel funding and seed venture capital, asset finance and blockchain approaches (Owen et al, 2019, 2018; Lehner et al, 2019). Arguably, government policies have been light touch and limited, with early stage, small venture investor tax breaks such as those in the UK and Republic of Ireland, encouraging private investment, but potentially skewing investments towards shorter term digital technologies (funding 'digitech' companies specializing in software and online solutions) which offer faster returns (Baldock and Mason, 2015). More needs to be done to encourage, legitimize and mainstream impact investing (Lehner et al, 2019) and to demonstrate to both investors and

policymakers that investments are contributing to creating a low carbon circular economy and therefore contributing to a net reduction of greenhouse gas emissions and reaching the climate goal (Rizos et al, 2016).

From an environmental impact investor's perspective there is limited knowledge of how innovation will reduce carbon emissions and there is often insufficient remuneration to build a strong business case for investment. This situation is exacerbated when, as is frequently the case with Cleantechs, the innovation is long horizon, capital intensive and very high risk (Rowlands, 2009; HM Treasury, 2017). This scenario inevitably results in under investment, particularly in earlier higher risk and longer horizon investments where funds may be locked-in for five or more years, with considerable uncertainty (Gaddy et al, 2017). These factors are contributing to an enormous, highly challenging funding gap. At a global level, the study by UNFCCC (2014) calculated this gap to be in the region of \$70bn plus.

Those calling for rapid government actions, which include declarations of climate emergencies and Green New Deals (The Guardian, 2019) are becoming aware of the enormity of the task and wide-ranging potential mitigation steps required (Kern et al, 2019). Whilst there is growing consensus that there is a need for policy intervention, there is also a confusing and complex array of policy responses and instruments (Owen et al, 2019, 2018) which currently lack coherency. There is, therefore, a need for further research to generate bridges between innovation, finance and policy studies (Owen et al, 2019; Kern et al, 2019) and inform policy development of the boundary spanning and more co-ordinated response required to encourage environmental impact investing and a clearer pathway to global low carbon and circular economy solutions (Lehner et al, 2019; Rodriguez et al, 2020).

Existing green finance has been growing with the greater focus for national policies and international collaborations (World Bank and European Union) on leveraging private sector finance for larger scale infrastructural transport and energy projects (Owen et al, 2018). For example, the UK government-backed Green Investment Bank raised £12bn in government and private co-finance between 2012-17, much of which led to the rapid development of the UK wind farm sector (National Audit Office, 2017). Furthermore, the announcement of a UK Green Investment Strategy (HM Government, 2019) and Green Investment Institute, proclaiming globally leading green finance policy, makes scant reference to supporting impact investment funding for early stage Cleantech SME innovation (Gaddy et al, 2017; Bürer and Wüstenhagen, 2009). Other examples from Europe show similar lack of attention to the financing requirements of Cleantechs. For example, in Republic of Ireland, less than 1% of all Enterprise Ireland's venture capital funding activity was invested in cleantech in 2017 (Enterprise Ireland, 2017). Furthermore, the European Union's recently announced Green Deal (EU, 2020) follows a similar pattern to that of the UK strategy, with focus on infrastructure spending for just transition to a greener economy through transforming coalfield industries and, lowering energy bills and applying new green technologies to existing business activities.

The research gap

There has been a limited amount of research in the area of early stage Cleantech SME impact investment, but it is spread across many different disciplines and subject areas. To get an overview of the subject area, we reviewed the literature using Scopus (the largest global

database of peer reviewed literature and abstracts). Taking consideration of issues around the contested nature of Cleantech definition (Bochen, 2015; Polzin, 2017), sustainability (Polzin, 2017) and environmental impact investing (Lehner et al, 2019) we adopted a broad search criteria, to include the following word search strings:

Finance* AND (start-up* OR early-stage OR venture-capital) AND (green* OR renewable* OR clean-tech* OR environment* OR sustainab*).

This produced 50 peer reviewed articles published in the last decade (from 2010 onwards) where abstracts addressed Cleantech SMEs' finance (a further 24 articles addressed sustainable finance for larger businesses). Using a snowballing process, an additional 15 relevant peer reviewed papers referred to in other work were added.

Table 1: Systematic Literature Review 2010-2018

Scopus Search (abstract content results)	Number of Articles
Sustainable (impact) investment and early stage (innovation)	31
Sustainable investment, early stage and policy	19
Snowballing (additional relevant articles)	
Sustainable investment and early stage	4
Sustainable investment, early stage and policy	11
Total	65

What is immediately apparent from this search is the small number of directly relevant articles, and that under half are policy orientated (Table 1). There is also an indication of the interdisciplinary nature of the research required to tackle this subject. This includes entrepreneurial finance and wider business support ecosystems (Neumeyer and Santos, 2018) and innovation finance systems (Polzin, 2017), consideration of green definitions and alternative business models (Bocken, 2015; Rizos et al 2016), venture capital policy (Cumming et al, 2017) and wider public policy analysis (Mazzucato and Semieniuk, 2018), sector analysis with considerable focus on renewable energies (Gaddy et al, 2017; Lam and Law, 2018), institutional perspectives (Georgeson et al, 2014) and behavioural finance from entrepreneurial (Bergset, 2015) and different investor perspectives (Moon and Hwang, 2018). The literature also predominately examines mature SME markets in Europe and North America, with a few exceptions which discuss emerging markets (Biekpe, 2004). The wider emerging markets literature focuses on financing larger-scale renewable projects (Gramkow and Anger-Kraavi, 2018; Owen et al, 2018). The sample includes articles from a wide range of journals, further highlighting the dispersed and emergent nature of this discourse with multiple articles from Energy Policy, Journal of Cleaner Production, Sustainability and Venture Capital, amongst many others.

More specifically, this initial literature review provided very limited evidence of papers developing more integrated Green Deal type frameworks for policy support to assist innovative Cleantech SMEs (Owen et al, 2018; Mazzucato and Semieniuk, 2018). Casting our net more widely to include recent policy literature, Owen et al (2019) provide seed ideas for targeted Green Deal policy support to early stage innovative Cleantechs. Drawing on UK lessons in

stimulating public-private co-financed venture capital policy, they demonstrate triple bottom-line commercial, and socio-environmental benefits; notably in CO2 reduction and Cleantech patent generation and wider spillovers to greening supply-chains and broadening the UK's Cleantech R&D base. Sonnenschein's (2016) examination of lessons from Nordic countries (who are leading the way in achieving carbon neutrality), found that Cleantech innovation finance policy evaluation was little developed, with no standard accepted approach. His structured analysis of key performance indicators suggested that a key measurement is metric tons (Mt) of CO2 emission savings, but that this was only partially accepted. Whilst data at the macro national level, in terms of CO2 GDP intensity, has some robustness, key problems were encountered at the micro policy level. These notably include time-lags, reliance on estimations, lack of more rounded circular economy considerations and inconsistencies and manipulations in evaluations (referring to the problems of calculating return on investment (RoI) for longer horizon Cleantech investments). Kravchenko et al. (2020) highlight the problems of adopting key performance indicators (KPIs) to measure circular economy impacts, finding 270 potential KPIs which have been applied to larger manufacturing company activities in highly nuanced and different ways according to industry activity. They point to useful KPIs based around energy and material consumption throughout production, product life, repair, repurposing and recycling. Furthermore, Rodriguez (2020) makes a compelling argument for policy to consider both the ecological measure of increased renewable energy intensity (i.e. CO2 reduction in the national energy grid) and energy efficiency (i.e. producing more from a unit of energy).

Conclusions: Setting the agenda for future research

The need for a clear research and policy agenda to assist early stage Cleantech financing has never been greater. These businesses hold important keys to unlocking vital globally game changing technologies to tackle climate change. Our review of recent academic literature demonstrates considerable current deficiencies, but also helps to identify some avenues for further research.

Table 2: Scopus Systematic Literature Review of Key Search Terms (2000-2020)

Search Term	Number of Relevant Articles
Cleantech	11
Low carbon metrics	86
Low carbon economy	32
Environmental impact metric/indicator	47

Note: Relevant articles were obtained through screening Scopus search returned papers by key words and abstract content review.

Concerned by these apparent deficiencies we conducted an updated Scopus literature review of peer reviewed articles for key search terms relating to Cleantech, low carbon metrics and economy and environmental impact metrics and indicators during the last two decades (Table 2). The paucity of literature relating to Cleantech was demonstrated by the return of just 41 papers, which was further refined to just 11 papers where key words and abstracts demonstrated relevance to SMEs and/or impact finance. Several studies look at the role early stage Cleantech companies can play in the transition towards a low carbon green economy (e.g. Gosens, Lu and Coenen, 2015; Knuth, 2018; Hillman et al, 2018) or how Cleantechs crowdfund (Cumming et al, 2017a), and which policy approaches align best with such alternative funding (Bürer and Wüstenhagen, 2009). However, none of them effectively proposes policy

approaches that address the funding gaps given their complex company structure and processes. Paradoxically, there are larger numbers of papers that are relevant in terms of proposing environmental and low carbon economy metrics and KPIs, but these almost exclusively focus on larger companies and on matters such as policy regulation.

The review revealed complexity in developing effective metrics to assist policy approaches. Current environmental impact indicators are highly diverse, presenting companies, including SMEs, with a vast and confusing variety of choice. Some recent papers offer an overview of the types of topics (e.g. strategic approaches, energy impacts, circular economy considerations) that are deemed relevant in practice and research (Lou et al, 2019). Other papers analyse potential indicators (Kravchenko et al., 2020), but most provide nascent, yet very detailed insights into specific industries such as manufacturing, marine or oil. While all of these studies have the potential to add to a broader agenda, to date no study has delineated a sector-specific guideline on how to select relevant key indicators.

Hence, based on the above, we outline the following potential research directions: First, there is a need for greater understanding of Cleantech business typologies and their different financing needs (Corona et al, 2019; Bjornali and Ellingsen, 2014). For example, longer horizon, larger capital-intensive early stage investing is problematic, but which business models and approaches are more likely to attract investors and to succeed? What challenges do different types of cleantech ventures face for example emerging circular economy (Blomsma and Brennan, 2017) start-ups and SMEs?

Second, flowing from the first point, there is a need to develop a systems view that on the one hand maps early stage finance providers to cleantechs – to create a flowing green finance escalator (Owen et al, 2018; 2019) - but also takes on board the range of associated institutional, technological and policy/regulatory support functions to facilitate innovation development (Binz and Truffer, 2017). Borrowing from the literature on green niches (Smith, 2007) and policy mixes (Kern et al, 2019): What are the appropriate frameworks and actors in different institutional and cultural markets, at different levels of maturity?

Third, there is a gaping deficit in our understanding of how to encourage the significantly larger levels of private impact investing required to enable early stage cleantech innovators to impact on climate change. Public policy is often criticized for under-performing (Cumming et al, 2017) and skewing the market in unintended ways (Baldock and Mason, 2015). There appear to be two important strands here. On the one hand greater knowledge is required about the behaviours of investors and entrepreneurs (Bergset, 2018) to inform on the other hand which policies and nudges are most appropriate, taking into account different market circumstances?

Fourth, Owen et al (2018; 2019) call for improved policy evaluation metrics, which take into account the full impact of cleantech investments, versus non cleantech. Rizos et al (2016) highlight financial challenges facing emerging circular economy start-ups and SMEs (a particular sub-set of clean-tech) , whilst Owen et al (2019) start to consider what investor metrics and approaches are best suited for early stage investors and Lehner et al (2018) combine accounting practices with questions around what legitimizes investing?

Finally, given the increasingly global financing economy Brandstetter and Lehner (2015) pose the question as to what is required to encourage cross-border standards, harmonization and cohesion to encourage the flow of inward investment to Cleantechs. Ultimately what are the best solutions for local, national and international markets to achieve a global low carbon circular economy?

Note: IEEE Transaction on Engineering and Management has a call for papers concerning this issue:

Entrepreneurial Finance for Green Innovative SMEs

<https://www.ieee-tems.org/2019/03/03/call-for-papers-entrepreneurial-finance-for-green-innovative-smes/>

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